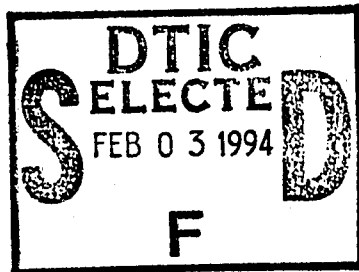ROBOT ASSISTED MATERIAL HANDLING

FOR SHIRT COLLAR MANUFACTURING

AUTOMATED SHIRT COLLAR
MANUFACTURING

DLA 900-87-0017 Task 0004

CENTER FOR ADVANCED MANUFACTURING

CLEMSON
UNIVERSITY
College of Engineering
Clemson, South Carolina 29634

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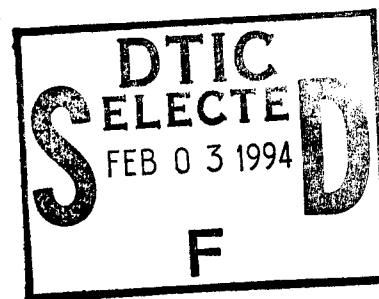
FINAL REPORT

Volume I:

Executive Project Review and Summary

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Frank W. Paul
Principal Investigator

Center for Advanced Manufacturing
and
Clemson Apparel Research

Clemson University
Clemson, South Carolina

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This document presents Volume I of the report on research into automated shirt collar manufacturing. It provides the executive review and summary of the project, as detailed in Volumes II, III, IV, V and VI of this project.

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ADVANCED AUTOMATION FOR SHIRT-COLLAR TURNING AND PRESSING

INTRODUCTION

This project work was initiated with the interest of addressing the technology needed to automate shirt-collar turning and pressing. Shirt-collar turning and pressing processes are currently performed by manual operators on a variety of industrial machines which use a single-point turning and pressing process. This work was undertaken by a team of graduate research assistants and the principal investigator under the review of an advisory board composed of representatives from the apparel industry and academic community.

Automated Collar Turning and Pressing

The current practice of manual turning and pressing depends on skilled machine operators to turn the collar inside out while "pointing" the collar, and aligning the collar seam edges for pressing prior to run stitching. This operator-assisted process is accomplished for a single collar point at a time in a sequential fashion, as shown in Figure 1. A desirable goal is to automate the turning and pressing of both collar points at the same time to create "double-point" turning and pressing processes. The understanding of these two processes has the potential for creating an evolutionary integrated collar-turning and pressing machine.

The research and development on the turning and pressing processes was accomplished by creating a proof-of-concept systems workstation, where a robot with a limp material-handling end-effector would sequentially load and unload turning and pressing machines based on the double-point concept. Technical solutions for the limp material-handling end-effector, the double-point turning machine, the double-point collar edge alignment/pressing machine, and the systems planning and hierarchical integration of the robot and two machines were addressed in this research.

AUTOMATED COLLAR TURNING AND PRESSING WORKSTATION

The critical technological issues of producing quality collars relates to inverting and pointing the collar, and aligning the collar edge prior to pressing. Producing a quality turned and pressed collar requires a sharp point during the turning process and the proper alignment of the pressed collar edge to achieve a pair of smoothly contoured, sharp and matched collar points.

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The development of the double-point turning and pressing technologies focused on individual solutions for each process. These solutions were placed in the context of evaluating the applicability of material-handling robots to apparel manufacturing. This resulted in the development, understanding and evaluation of an apparel workstation composed of a collar destacker, collar turner, collar edge alignment/presser, and robot for collar handling. Figure 2 shows a schematic of the workstation configuration. This workstation included the capability of exploring how computer-based hierarchical control concepts may assist an apparel operator to plan and control workstation activities, including replanning and workstation process error recovery. The following sections address the technology of the robot apparel end-effector, the turning machine, the edge alignment/presser machine, and the control and operation of the workstation system.

Apparel End-Effector Technology

An apparel end-effector designed to handle limp fabric is shown in Figure 3. This end-effector was designed in such a way to acquire both unturned and turned collars, load and unload the turner and presser machines, center the collar, tension the collar fabric for positioning in the machines, and orient the collar in a vertical plane. This device was attached to an Adept 1 industrial robot for collar handling in the workstation. The end-effector controls were integrated into the workstation operation, and included servo and stepper motor positions and gripper operation. All actions of the end-effector were activated through the system supervisory controller which was coordinated with the robot controller, as indicated in Figure 2.

Double-Point Turning Machine Technology

A double-point collar-turning machines was conceived by considering a variety of techniques to invert the collar pocket. These techniques ranged from the use of tubes to vacuums to pivoting mechanisms. The resulting concept was based on double-point pivot turning using pointing elements similar to the clipper and turner components found on commercial single-point turner/ presser machines. Figure 4 shows the developed double-point proof-of-concept turning machine.   .

In excess of 200 collars have been turned with this proof-of-concept machine. Figure 5 shows a comparison of a collar turned single point at a time on a commercial machine with a collar turned both points at a time on the new concept machine. Observation of this Figure shows that the collars have similar geometric points, with some collar "puffing" owing to excess material inside the collar point. An important requirement for the use of this highly productive double-point turning technology will be to ensure the quality of the trimming action on the unturned collar tip prior to the turning operation.

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Edge Alignment/Pressing Machine Technology

Figure 6 shows the operator-controlled process of turned collar edge alignment prior to insertion into a commercial turning and pressing machine. This process requires considerable operator hand, finger and eye coordination to ensure that the collar seam edge is correctly positioned with respect to the pressing creaser blade. This process is skill-based and demands a significant amount of operator cycle time and attention to ensure a quality pressed collar. The automation of this process requires the geometric knowledge of the seam collar edge so that it can be physically located with respect to the creaser blade.

An automated edge detection/alignment pressing machine was developed based on vision sensing and indirect rear collar edge matching. This method was selected from several concepts which considered the visual measurement and positioning of the collar seam location with respect to the creaser blade. Figure 7 shows the single-ply manipulation scheme in cross-section. The method requires that the original unturned collar components be precisely sewn together in such a way that the rear collar edges match. This constraint was investigated at the Clemson Apparel Research Shirt-manufacturing Facility and not found to be a limitation to this approach.

Figure 8 shows the edge alignment/presser machine system. This machine includes a collapsible creaser blade which is inserted into the turned collar pocket and then expanded for edge alignment purposes. A vision camera sensor is used to locate the top ply of the collar with respect to the bottom ply. Analysis has indicated that the vision camera sensor can be replaced by an appropriate set of LED sensors for positioning the top ply with respect to the bottom ply. This information is then used by the system supervisory controller to command the three alignment actuators to position the top ply edge with respect to the bottom ply edge. Figure 9 shows a visual comparison of the edge alignment and pressing results with the Clemson proof-of-concept machine (POCM) and a commercial single-point pressing machine.

## Integrated Workstation Control and Operation

Figure 10 shows photographs of the apparel workstation developed during this research to study automated double-point turning and pressing. A part of this workstation research was the knowledge and understanding associated with hierarchical control to achieve an acceptable man-machine planning and operating system. Figure 2 shows that significant mechatronic technology is required to plan, integrate, program and operate a workstation system composed of three computers, a robot, end-effector, vision-ranging system, vision-positioning system, turning machine and alignment/pressing machine. The operator interface technology needed to develop a plan and operating software is one of the limitations of most current automated manufacturing technology. Figure 11 shows the "star" computer hardware configuration with a system supervisor which interacts with the operator to plan and operate the system.

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The workstation control paradigm used was composed of an off-line planning level, and on-line computer coordination and hardware levels. The scheme for this paradigm is shown in Figure 12. The off-line operator planning software uses and expert system (C/Prolog) for assisting the operator to plan the workstation task required to complete a given job. This man-machine approach to operating a workstation does not require the operator to be an "expert systems" real-time programmer, but requires only his/her knowledge of the workstation operations and sequencing.

The operator is prompted and assisted by the expert-based systems software which is generically configured, as shown in Figure 13. All on-line real-time operational software is structured by the off-line expert system, downloaded to the appropriate computer, compiled (software is written in the C language) and then executed for controlling the workstation operation. The operation of the turning and edge alignment/pressing machines is shown in Figure 14 in conjunction with the material handling of the robot and fabric-handling end-effector. A videotape has been made which documents the real-time system operation.

CONCLUSIONS

The results of this research and development work have created a proof-of-concept workstation composed of *double-point turning and edge alignment/pressing machines*, and a material-handling robot and hierarchical control system which demonstrates the capability of enhancing the automation of shirt-collar manufacturing. The developed technology requires a Phase II continuation to create an integrated turning and pressing prototype machine, which can use industrial robot or operator-assisted loading and unloading. Such a prototype machine should be tested at the Clemson Apparel Research Facility and at a military apparel shirt-manufacturing site to ascertain the practical and economic benefits which may accrue to enhance the productivity of the shirt-manufacturing process.
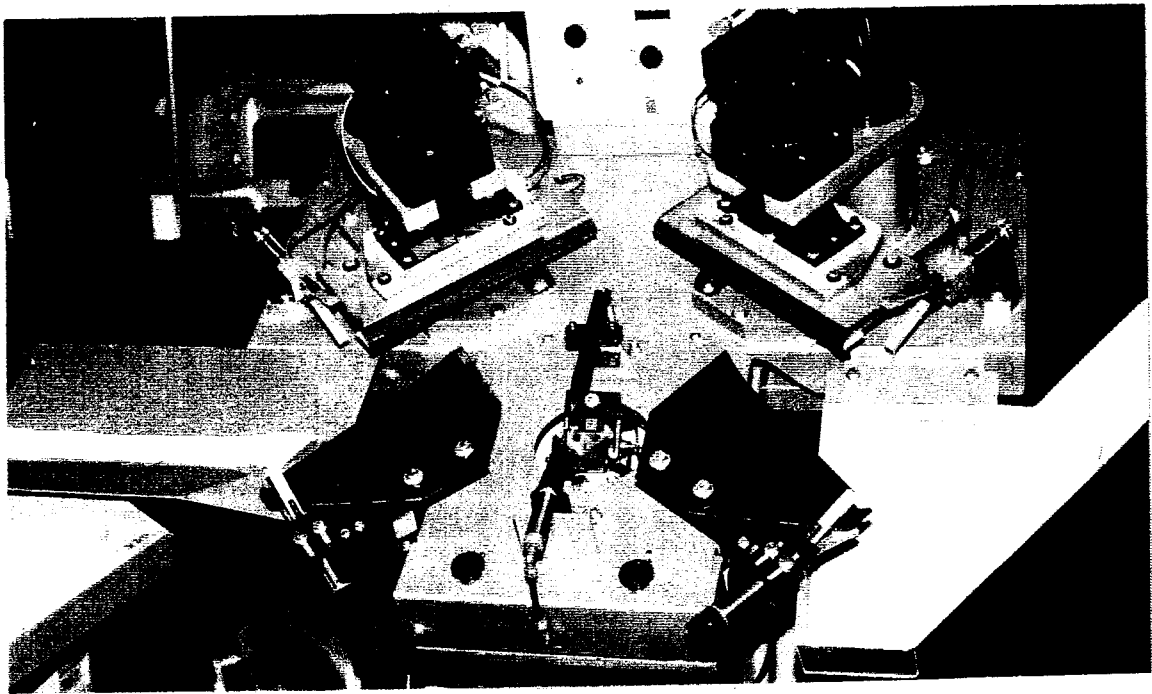
(a) Front view of machine
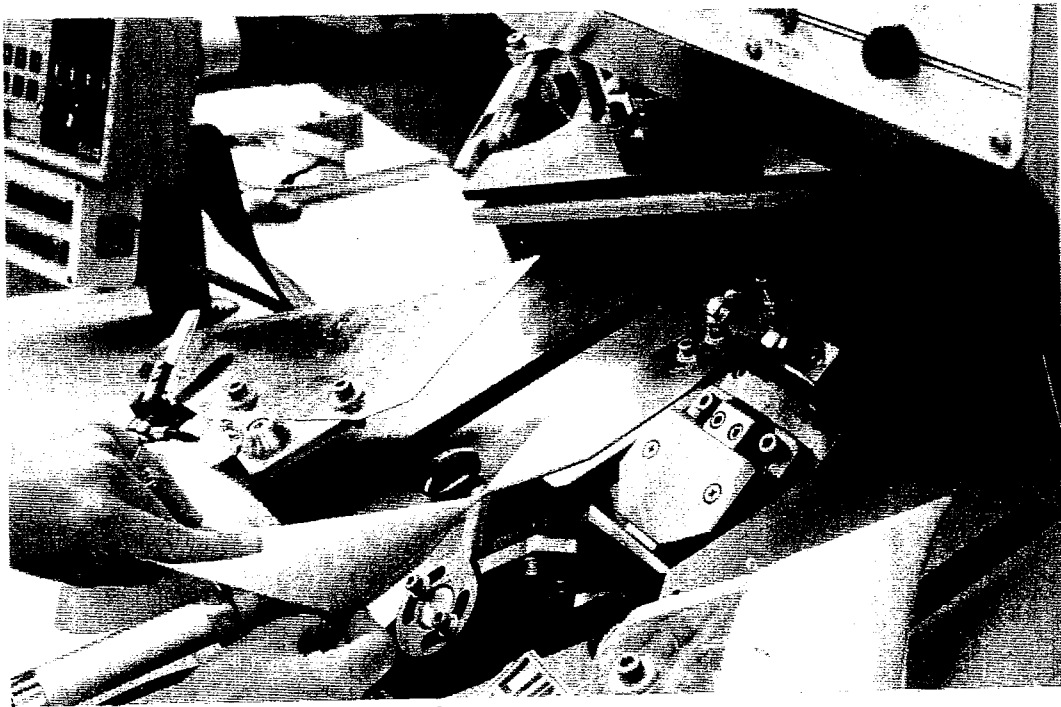
(b) Manual turning operation

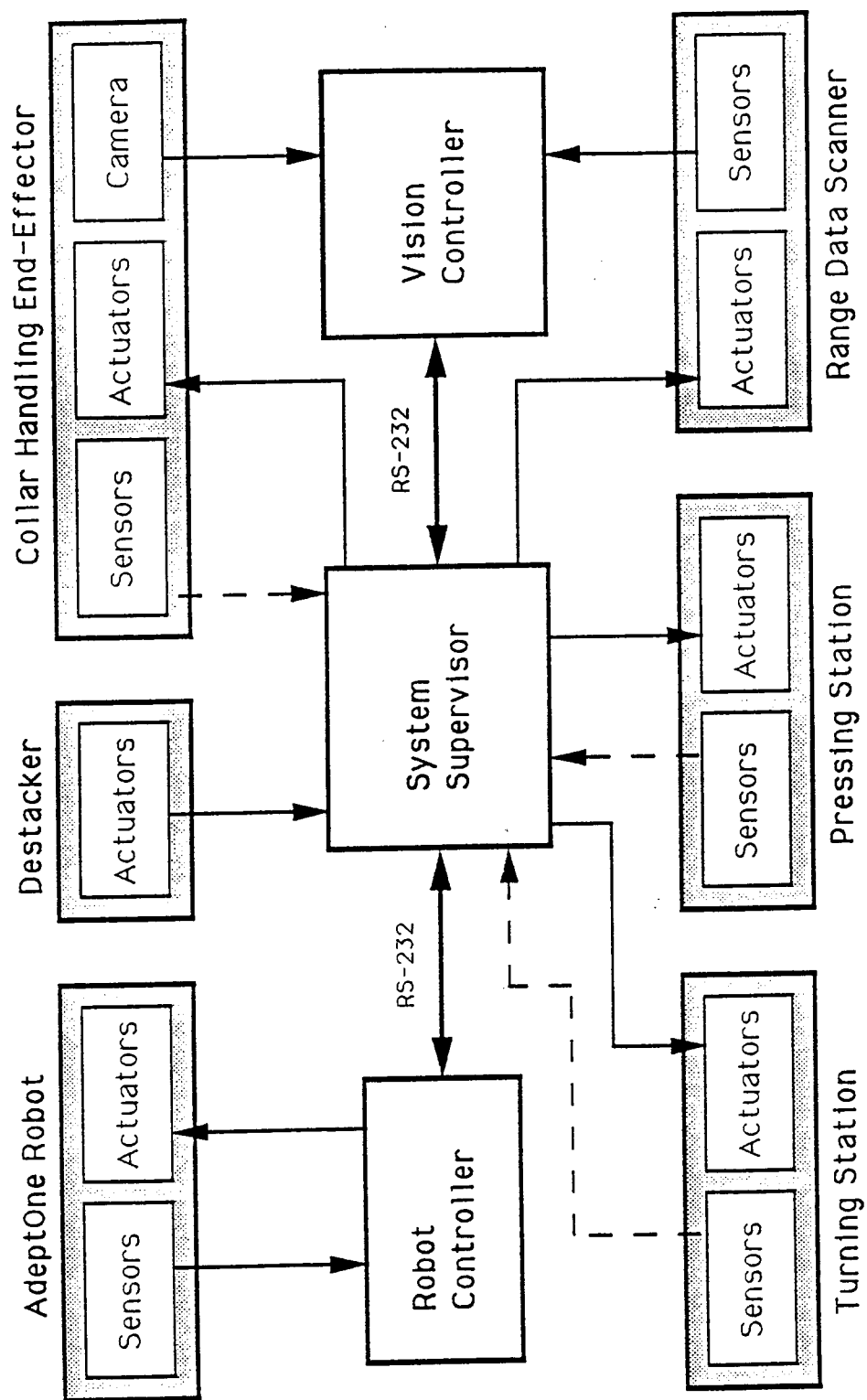Figure 1. Collar-turning and Pressing Machine
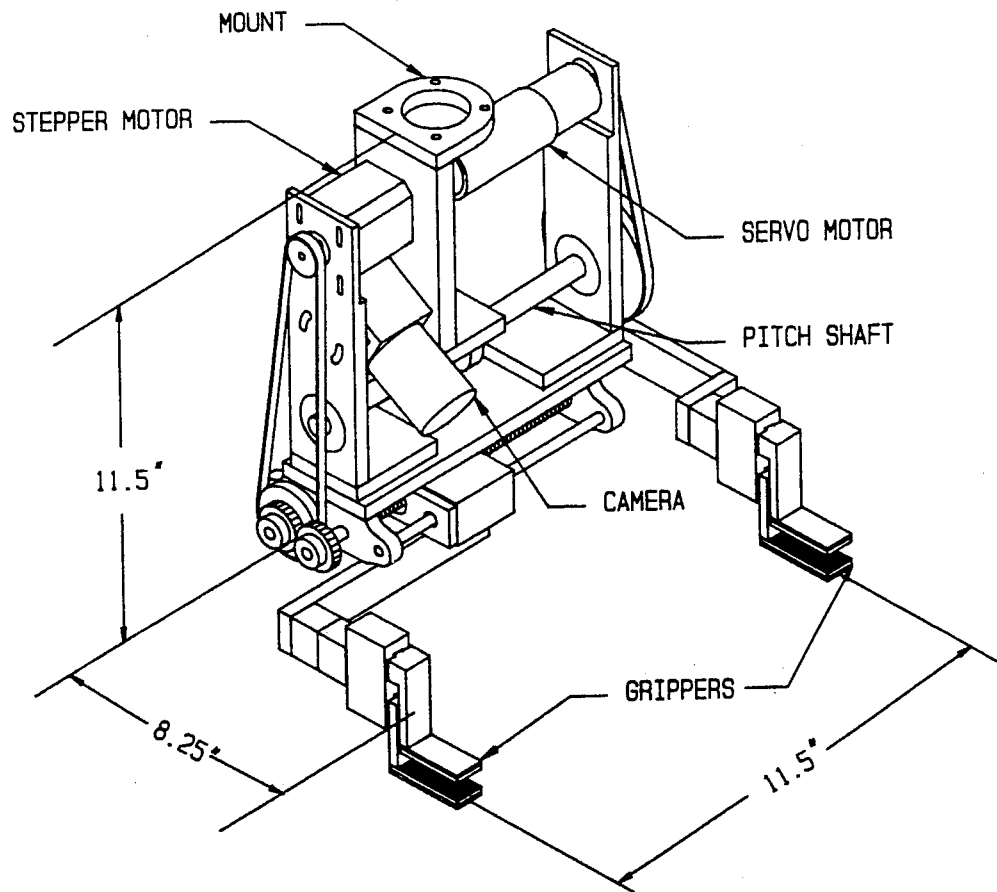
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Figure 2. AAW Configuration
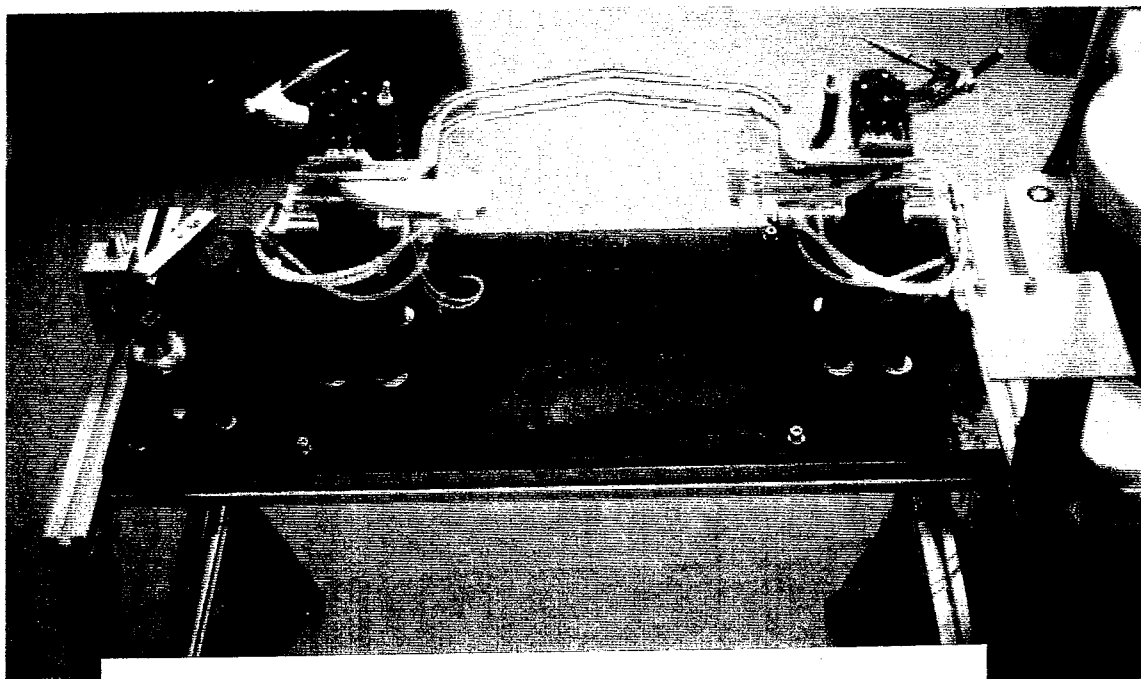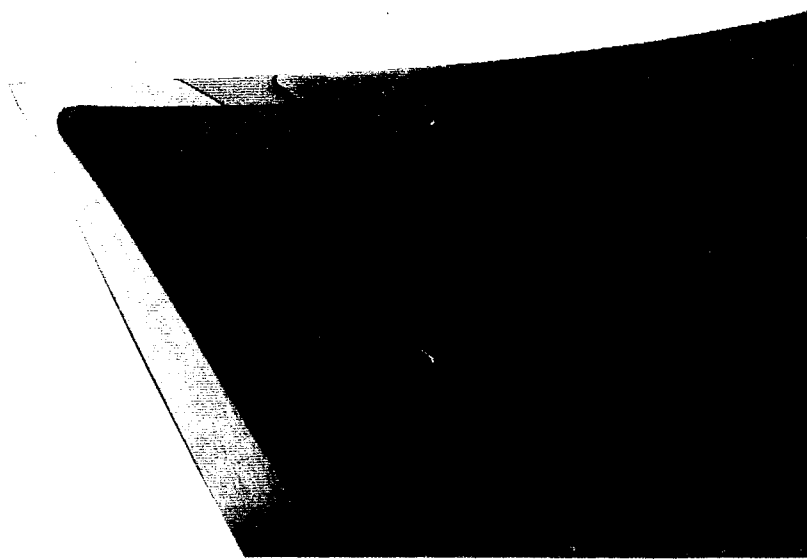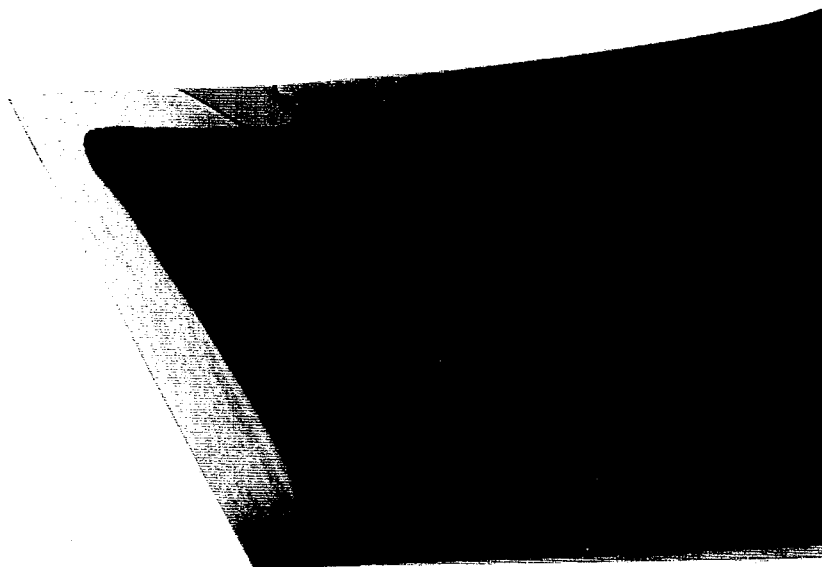
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Figure 3. Collar-handling End-effector

Figure 4. Double-point Turning Machine

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(a) The collar turned and pressed on the lunapress

(b) The collar turned on the turner and pressed on the lunapress
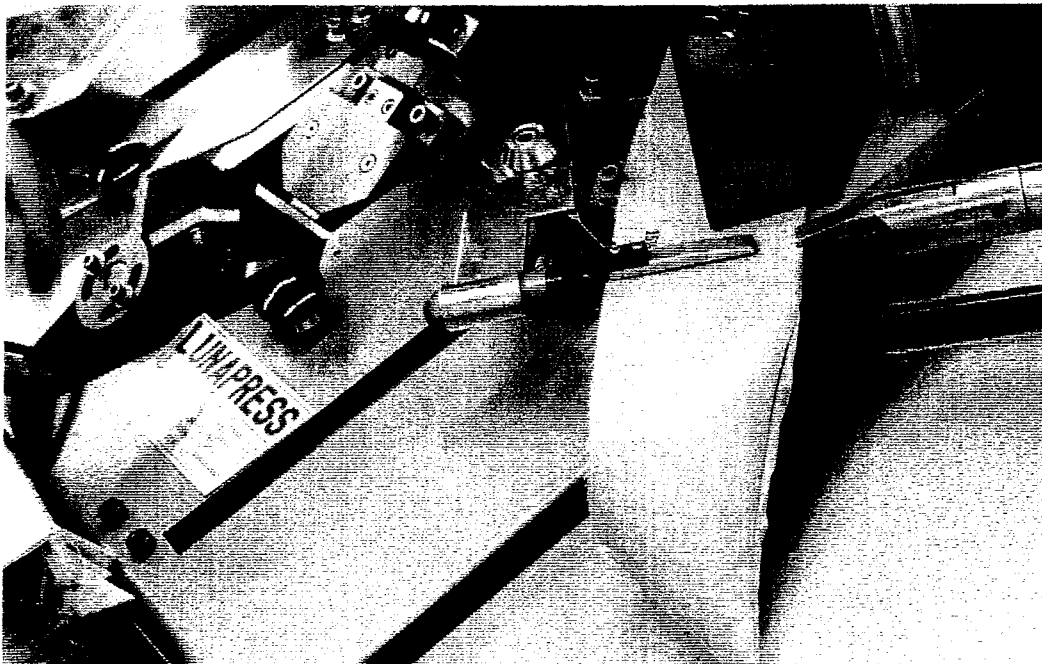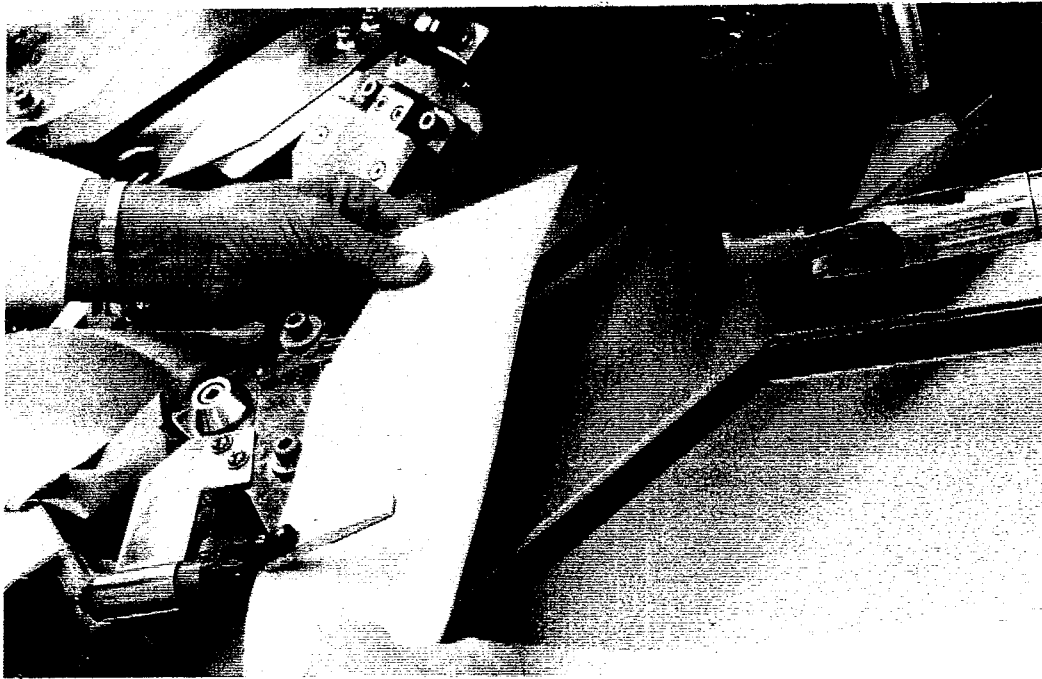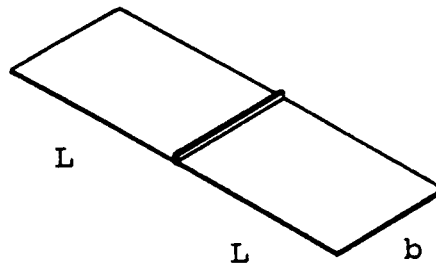
Figure 5. Quality of the Collar Point

Figure 6. Shirt-collar Pressing on the Lunapress
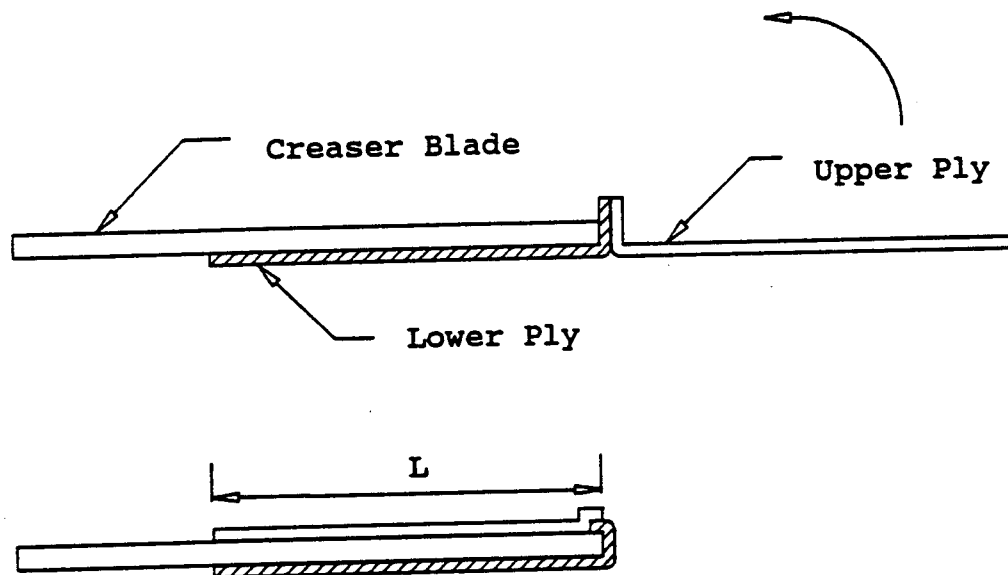
Apparel Workpiece

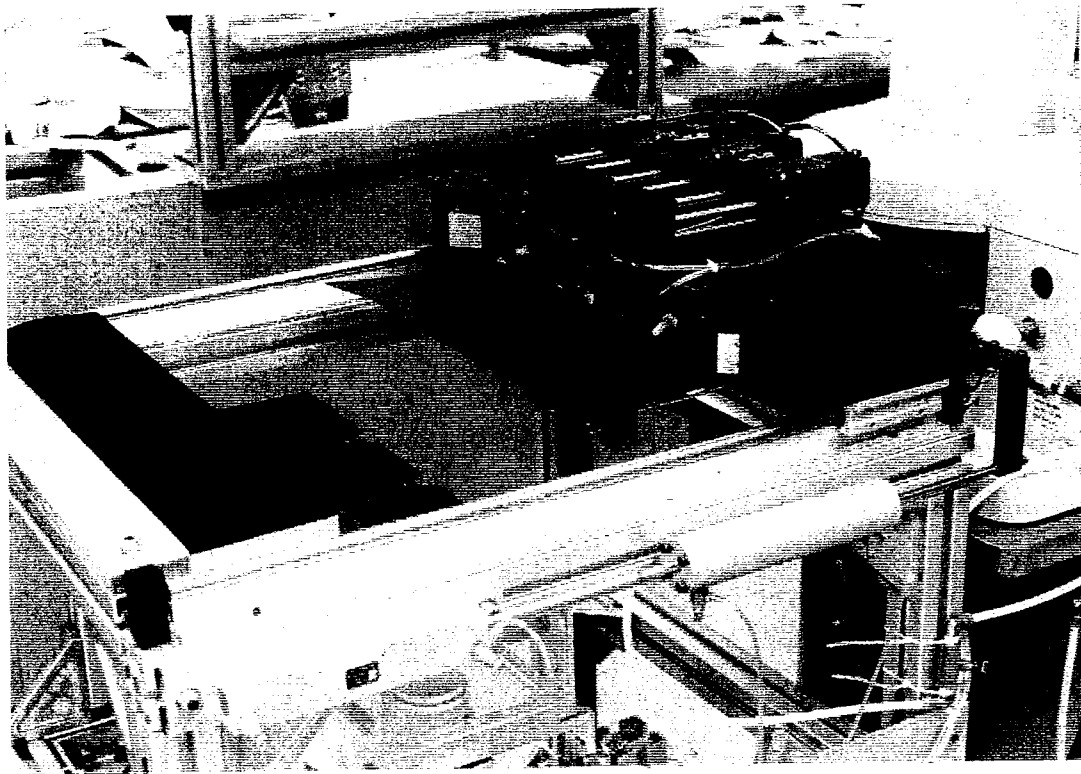Figure 7. Indirect Seam Alignment - Single-ply manipulation
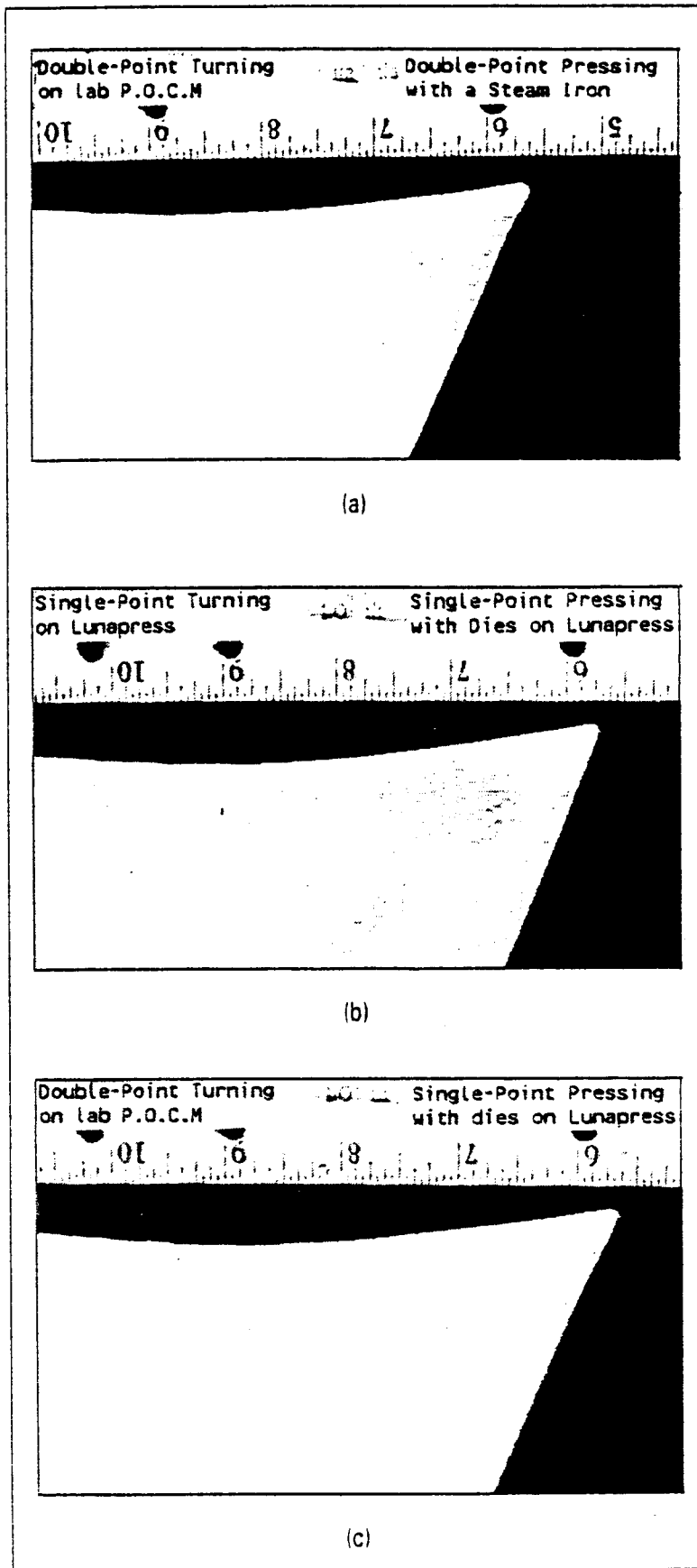
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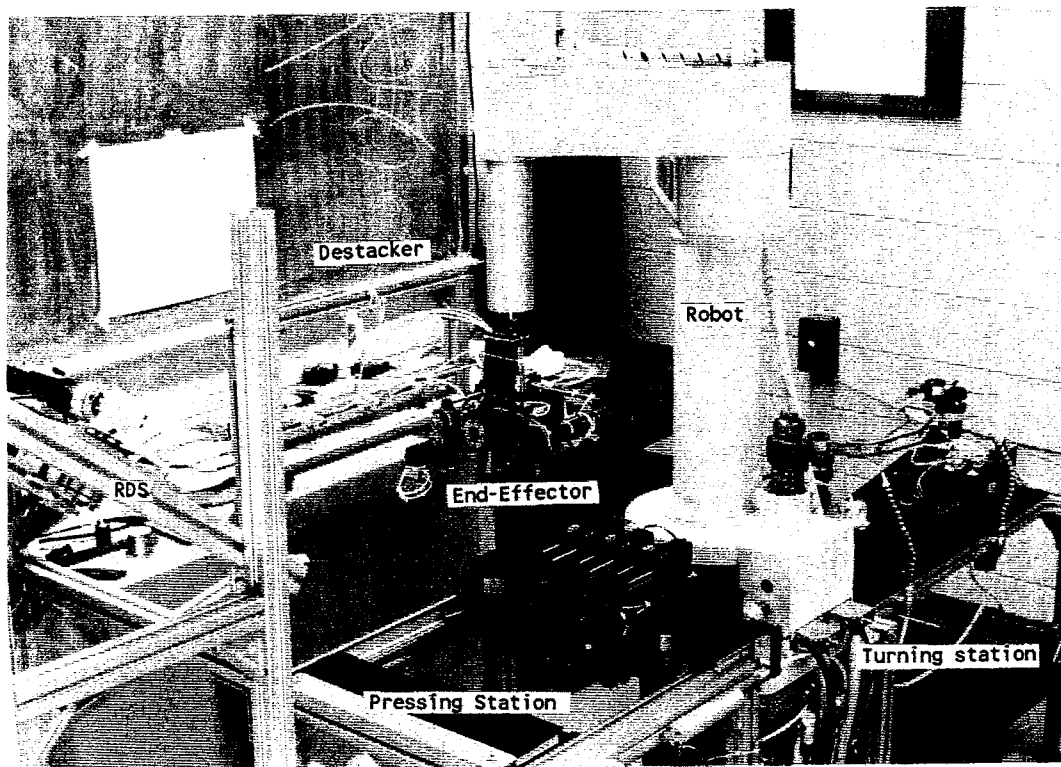
Figure 9. A Visual Comparison of Pressed Collars
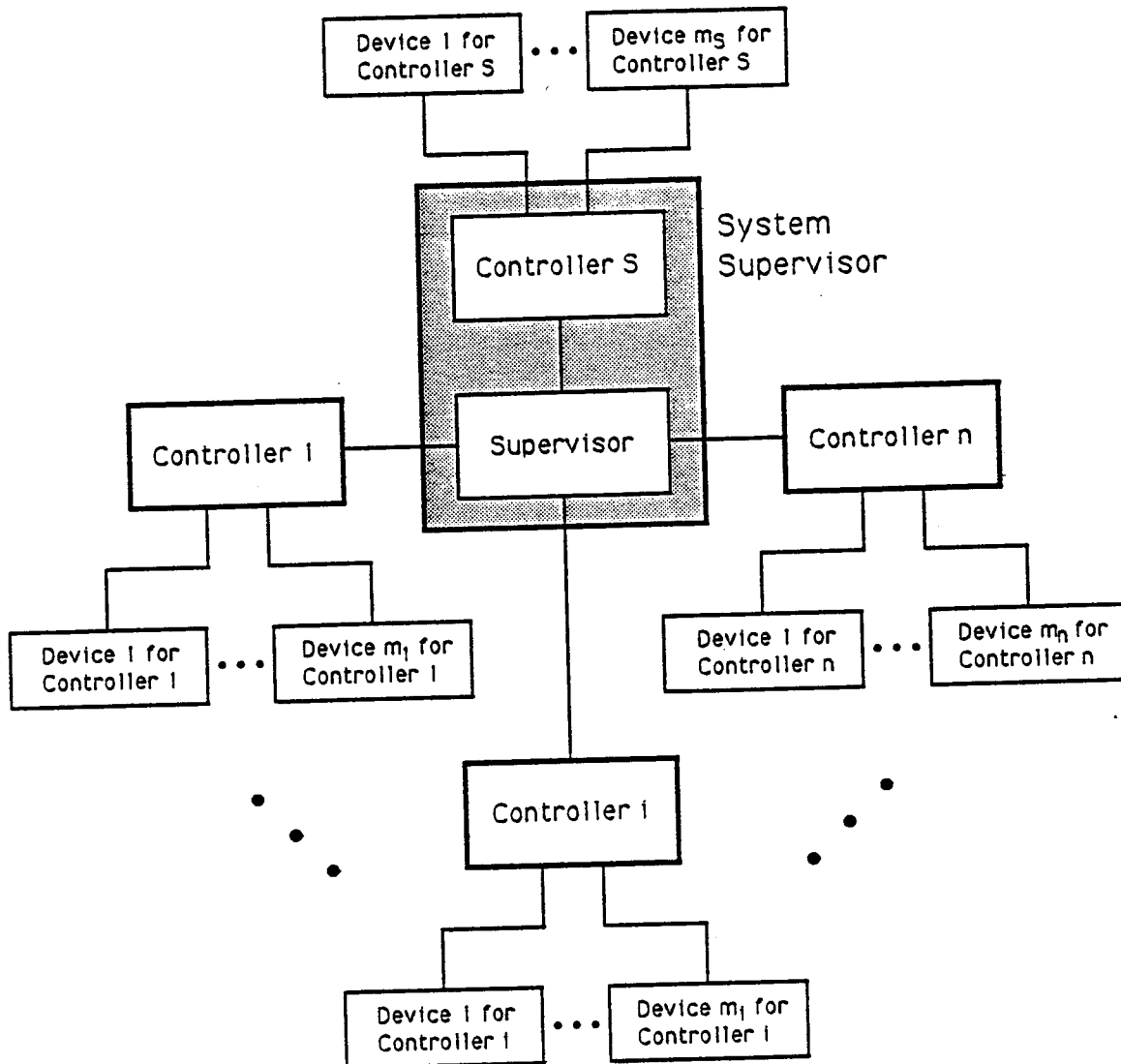
Figure 10. Apparel Assembly Workstation

Figure 11. Workstation Configuration

Planning Level

```
Workstation Job
Requirements

        "Planning"

                    User              Graphics          Rule-Base
                    Interface         Simulator         Systems

        Operator

                    Planning          Plan              Program
                    System                              Generator

    "Monitoring"                                    • • •
```

Coordination Level

```
    System Supervisor        Controller 1      • • •   Controller n
    Subplan                  Subplan                   Subplan
```

Hardware Level

```
                    Hardware Interface

    System Supervisor        Controller 1      • • •   Controller n
    Device(s)                Device(s)                 Device(s)


                            Object(s)
```
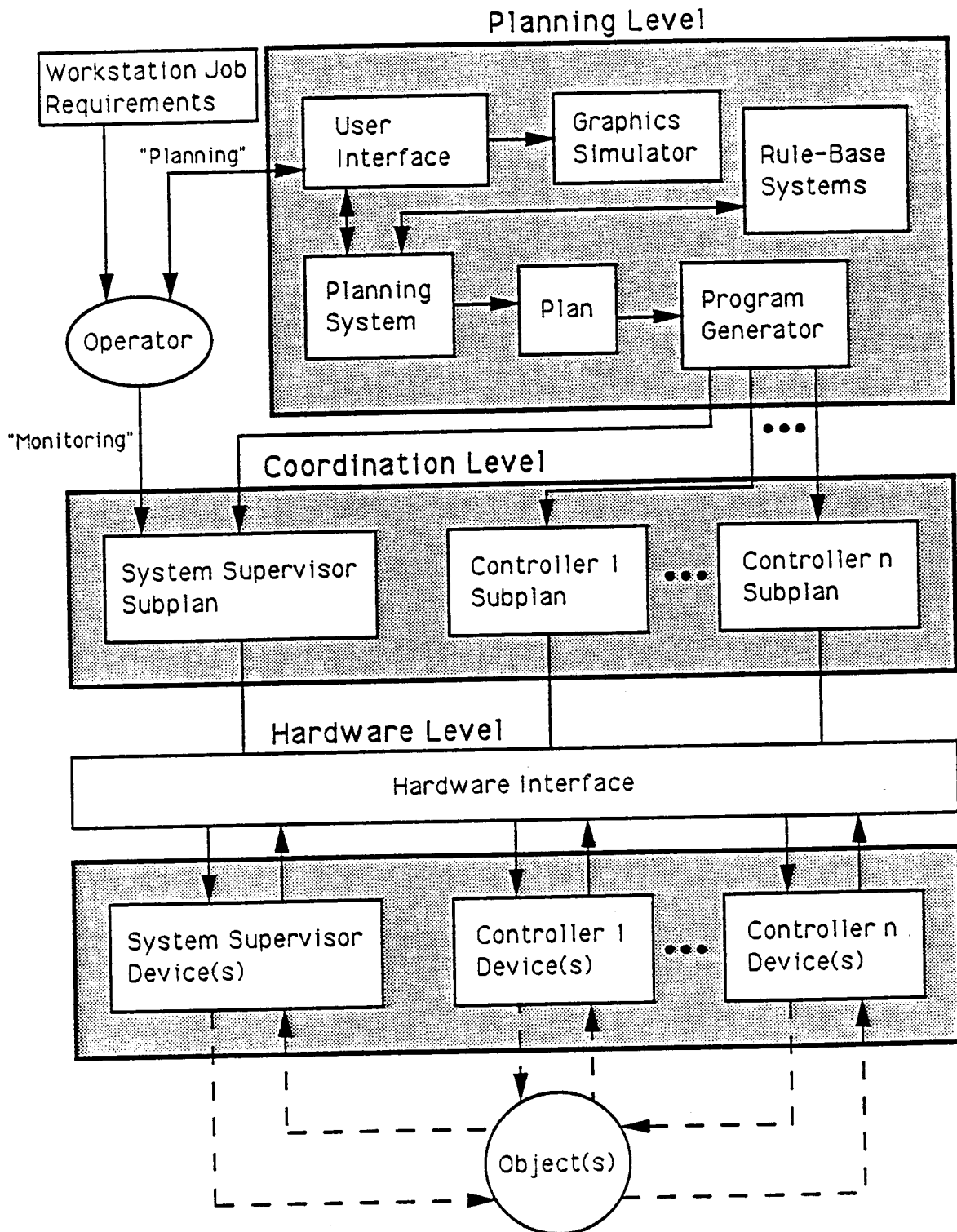
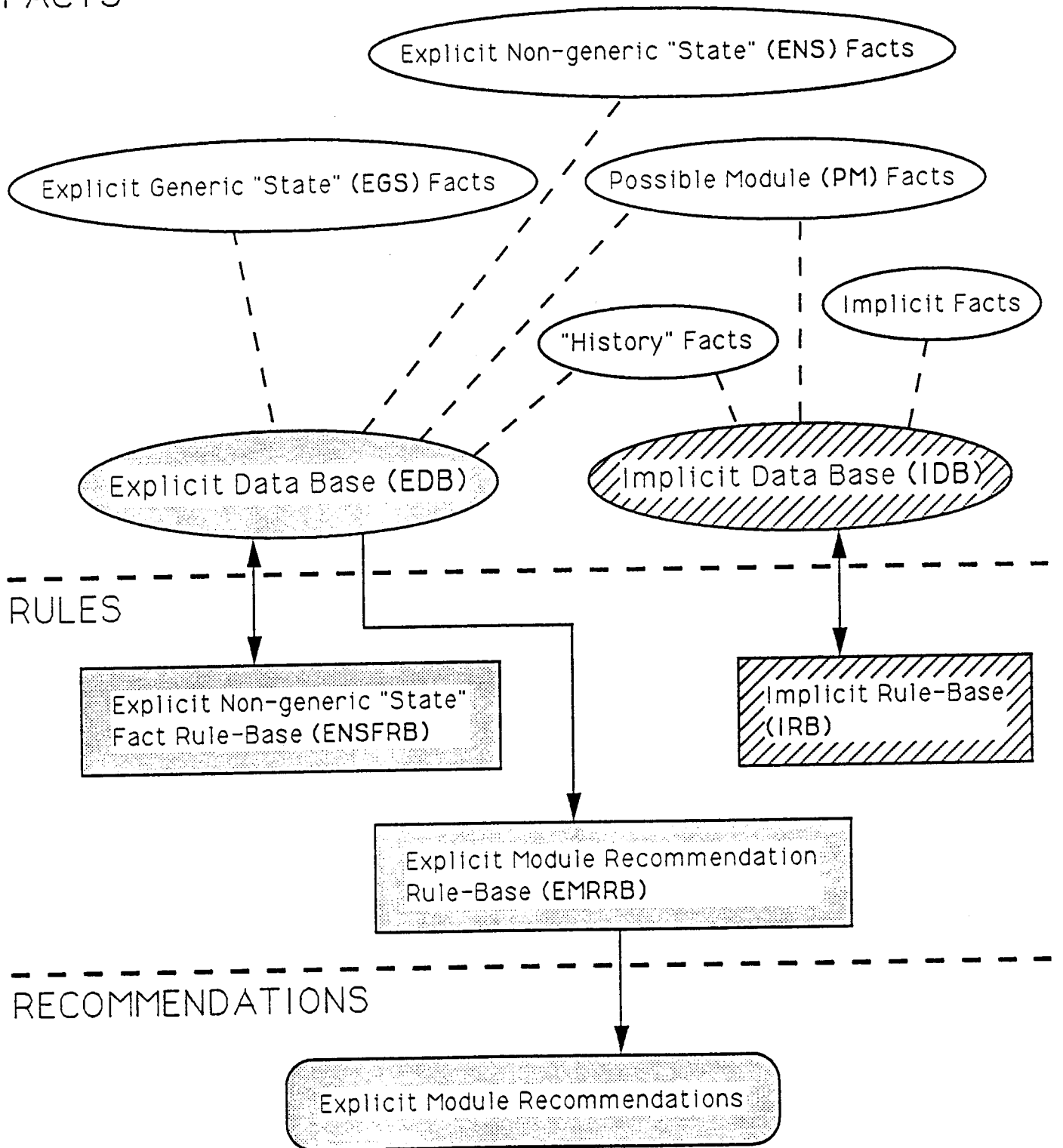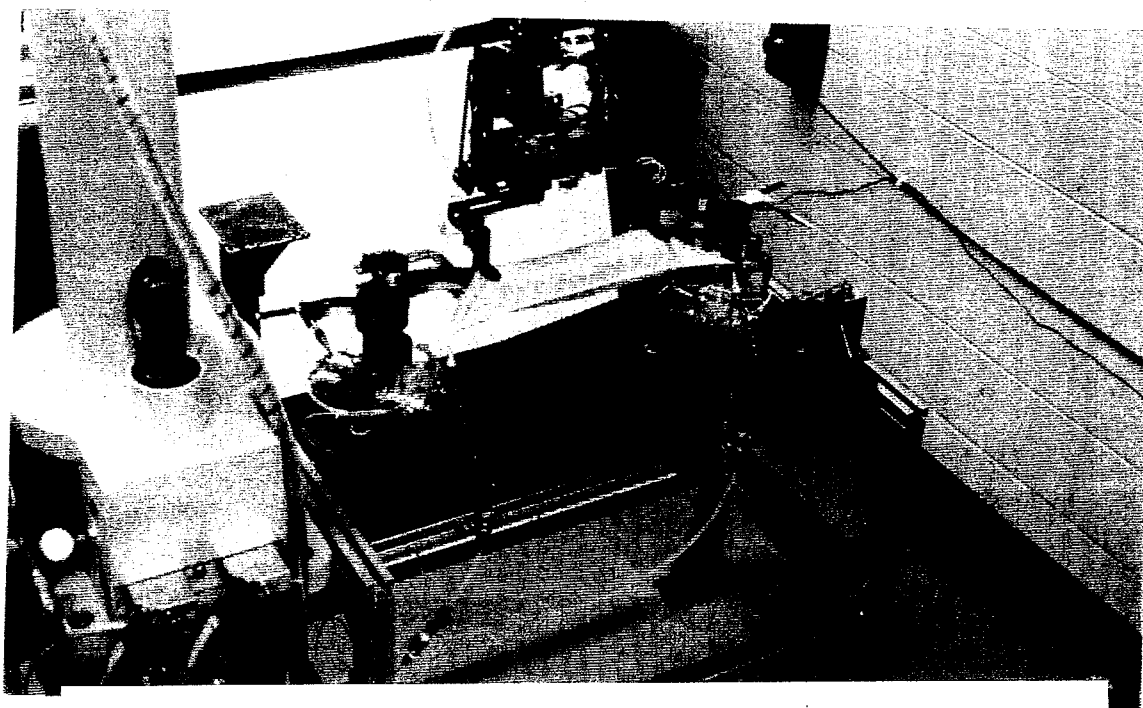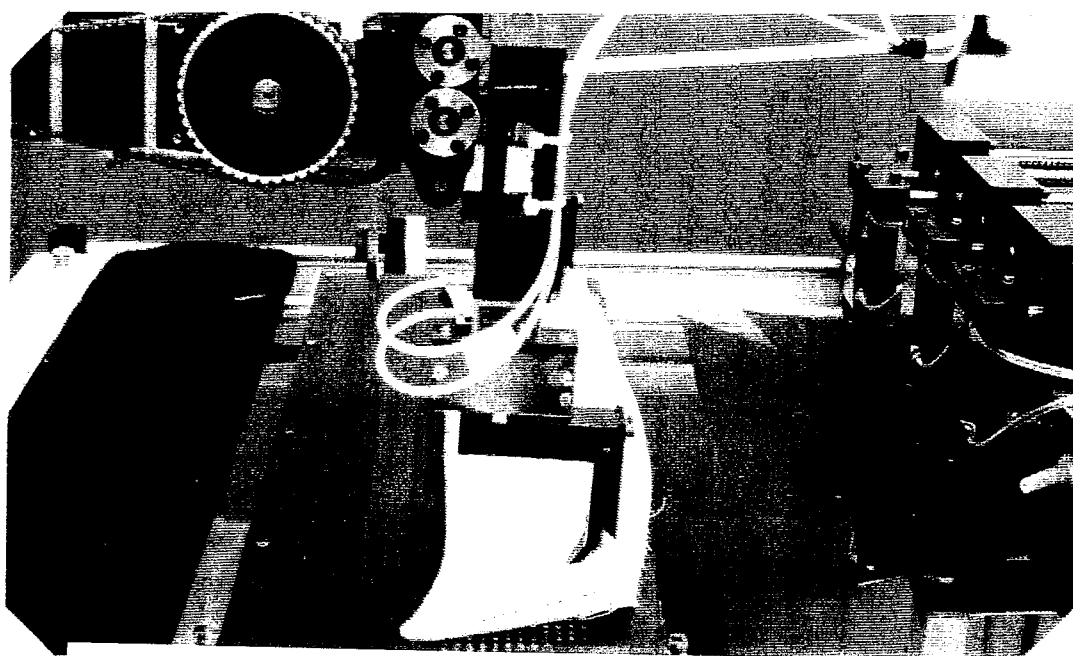Figure 12. Workstation Control Scheme

Figure 13. Organization of Databases and Rule-bases

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(a) Turning device loaded with unturned collar

(b) Pressing device loaded with turned collar

Figure 14. Device Loading